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AD6312

1/4- to 1/11 Duty VFD Controller/Driver

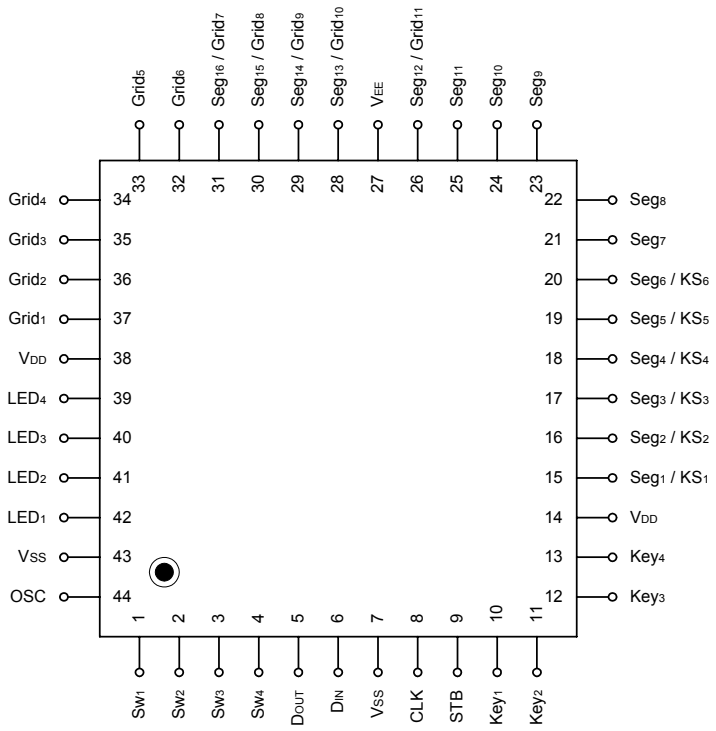
■ Features

- 4-pin serial interface
- Key scanning (6× 4 matrices)
- Programming display modes (11-segments & 11-digits to 16-segments & 6-digits)
- Programming dimming step
- High-voltage output (V_{DD}-35V max).
- 4 channels LED ports.
- 4-pin General-purpose input port
- Built-in oscillator
- No external resistor necessary for driver outputs

■ General Description

The AD6312 is a VFD (Vacuum Fluorescent Display) controller/driver that is driven on a 1/4- to 1/11 duty factor (include key scan). It consists of 5 segment output lines, 6 segment/key scan output lines, 6 grid output lines, 5 segment/grid output drive lines, a display memory, a control circuit, and a key scan circuit. Serial data is input to the AD6312 through a four-line serial interface.

■ Pin Assignments



Use all power pins.

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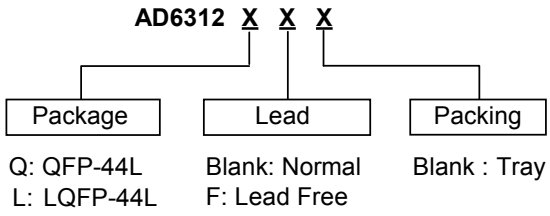
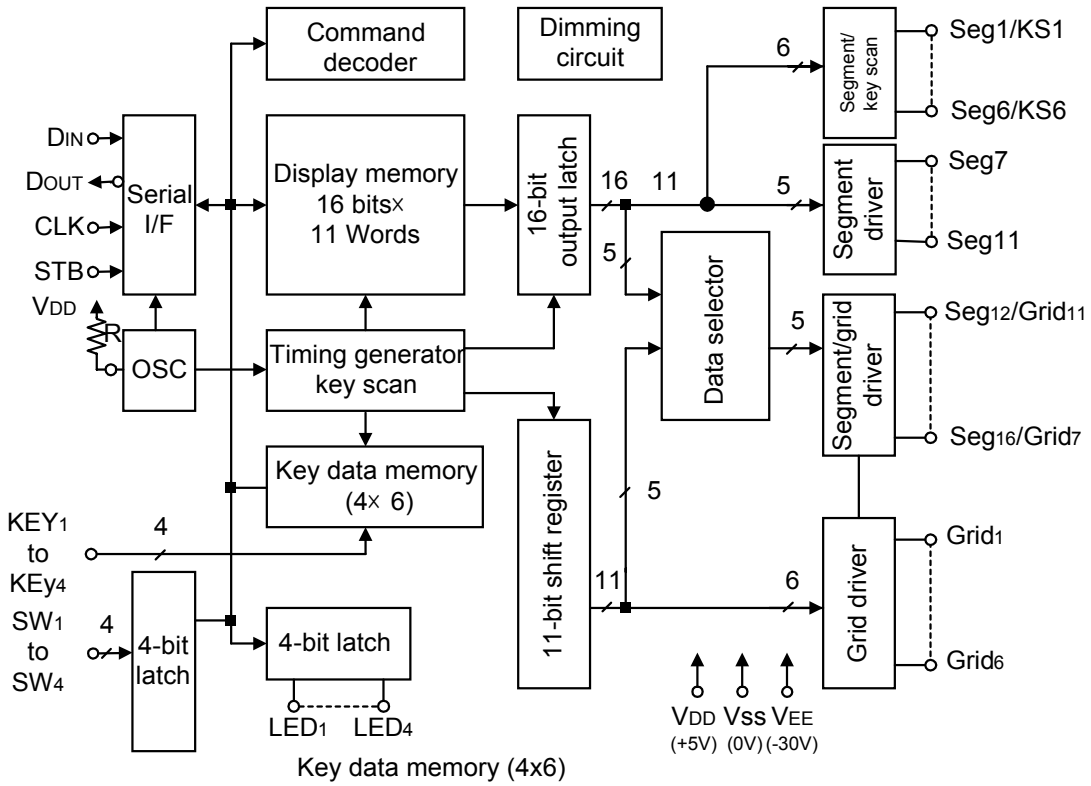
■ Pin Descriptions

Symbol	Name	No.	Description
D_{IN}	Data input	6	Input serial data at rising edge of shift clock, starting from the low order bit.
D_{OUT}	Data output	5	Output serial data at the falling edge of the shift clock, starting from low order bit. This is N-ch open-drain output pin.
STB	Strobe	9	Initializes serial interface at the rising or falling edge of the AD6312. It then waits for reception of a command. Data input after STB falling is processed as a command. While command data is processed, current processing is stopped, and the serial interface is initialized. While STB is high, CLK is ignored.
CLK	Clock input	8	Reads serial data at the rising edge, and outputs data at the falling edge.
OSC	Oscillator pin	44	Connect resistor in between this pin and Vss to set up the oscillation frequency.
Seg_7 to Seg_{11}	High-voltage output (Segment)	21 to 25	Segment output pins
Seg_1/KS_1 to Seg_6/KS_6	High-voltage output	15 to 20	Multi-function pins, Segment output pins (Dual function as key scan source)
$Grid_1$ to $Grid_6$	High-voltage output (Grid)	32 to 37	Grid output pins
$Seg_{12}/Grid_{11}$ to $Seg_{16}/Grid_7$	High-voltage output (Segment/grid)	26, 28 to 31	These pins are selectable for segment or grid driving.
LED_1 to LED_4	LED output	39to 42	CMOS output
KEY_1 to KEY_4	Key data input	10 to 13	Data input to these pins is latched at the end of the display cycle.
V_{DD}	Logic power	14, 38	Logic power supply
V_{SS}	Logic ground	7, 43	Connect this pin to system GND.
V_{EE}	Pull-down level	27	Driver power supply
SW_1 to SW_4	Switch input	1 to 4	These pins constitute a 4-bit general-purpose input port.

■ Ordering Information



■ Block Diagram



■ Absolute Maximum Ratings (T_A=25°C,V_{SS}=0V)

Parameter	Symbol	Rating	Unit
Logic Supply Voltage	V_{DD}	-0.5 to +7.0	V
Driver Supply Voltage	V_{EE}	V_{DD} +0.5 to V_{DD} -40	V
Logic Input Voltage	V_{I1}	-0.5 to V_{DD} +0.5	V
VFD Driver Output Voltage	V_{O2}	V_{EE}-0.5 to V_{DD} +0.5	V
LED Driver Output Current	I_{O1}	+15	mA
VFD Driver Output Current	I_{O2}	-40 (grid) -15 (segment)	mA
Operating Ambient Temperature	T_{OPT}	-25 to +85	°C
Storage Temperature	T_{STG}	-50 to +125	°C

■ Operating Conditions (T_A=0 to +70 °C,V_{SS}=0V)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Logic Supply Voltage	V_{DD}		4.5	5	5.5	V
High-Level Input Voltage	V_{IH}		0.7·V_{DD}		V_{DD}	V
Low-Level Input Voltage	V_{IL}		0		0.3·V_{DD}	V
Driver Supply Voltage	V_{EE}		0		V_{DD}-35	V

■ DC Characteristics (T_A=0 to 70 °C, V_{DD}=4.5 to 5.5V, V_{SS}=0V, V_{EE}=V_{DD}-35V)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
High-Level Output Voltage	V_{OH1}	LED_1-LED_4, I_{OH1}=-1mA	0.9V_{DD}			V
Low-Level Output Voltage	V_{OL1}	LED_1-LED_4, I_{OL1}=12mA			1	V
Low-Level Output Voltage	V_{OL2}	D_{OUT}, I_{OL2}=2mA			0.4	V
High-Level Output Current	I_{OH21}	V_O=V_{DD}-2V, Seg_1 to Seg_{11}	-3			mA
High-Level Output Current	I_{OH22}	V_O=V_{DD}-2V, $Grid_1$ to $Grid_6$ Seg_{12}/$Grid_{11}$ to Seg_{16}/$Grid_7$	-15			mA
Driver Leakage Current	I_{OLEAK}	V_O=V_{DD}-35V, driver off			-10	μA
Output Pull-Down Resistor	R_L	Driver output	50	100	150	kΩ
High-Level Input Voltage	V_{IH}		0.7V_{DD}			V
Low-Level Input Voltage	V_{IL}				0.3V_{DD}	V

■ AC Characteristics (T_a=0 to +70 °C,V_{DD}=4.5 to 5.5 V, V_{EE}=-30V)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Oscillation Frequency	f_{OSC}	R=51 kΩ	350	500	650	KH_Z
Maximum Clock Frequency	$f_{max.}$	Duty=50%			1	MH_Z
Clock Pulse Width	PW_{CLK}		500			ns
Strobe Pulse Width	PW_{STB}		1			μs
Data Setup Time	t_{SETUP}		100			ns
Data Hold Time	t_{HOLD}		100			ns
Clock-Strobe Time	$t_{CLK-STB}$	CLK ↑ →STB ↑	1			μs
Wait Time	t_{WAIT}	CLK ↑ →CLK ↓ (Note)	1			μs

Note : Refer to page 8.

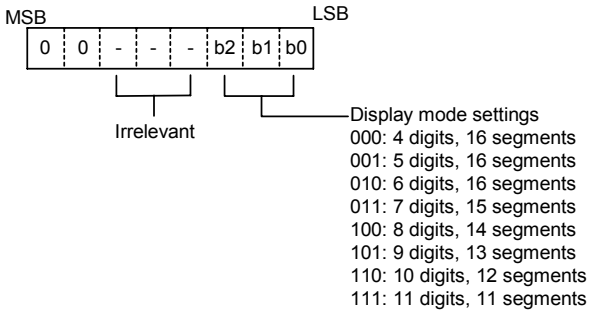
■ Function Descriptions

1.0 Commands

Commands set the display mode and status of the VFD driver. The first 1 byte input to the AD6312 through the D_{IN} pin after the STB pin has fallen is regarded as a command. If STB is set high while a commands/data are transmitted, serial communication is initialized, and the commands/data being transmitted are invalid (however, the commands/data previously transmitted remain valid).

1.1 Display mode setting commands

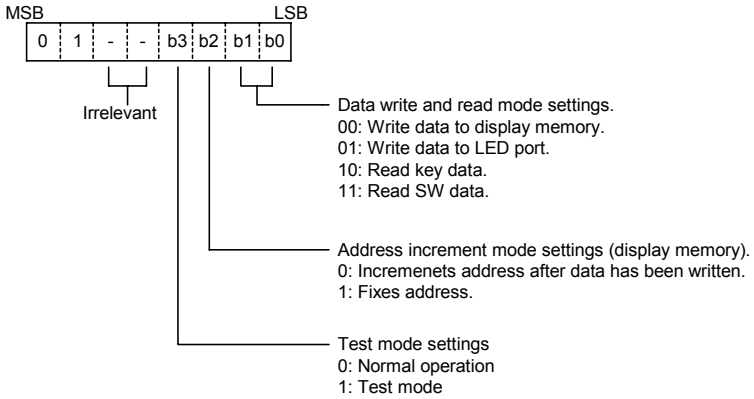
These commands initialize the AD6312 and select the number of segments and the number of grids (4 grids & 16 segments to 11 grids & 11 segments to). When these commands are executed, the display is forcibly turned off, and key scanning is also stopped. To resume display, the display command “ON” must be executed. If the same mode is selected, however, nothing happens.


MSB
LSB
0 0 - - - b2 b1 b0
Irrelevant
Display mode settings
000: 4 digits, 16 segments
001: 5 digits, 16 segments
010: 6 digits, 16 segments
011: 7 digits, 15 segments
100: 8 digits, 14 segments
101: 9 digits, 13 segments
110: 10 digits, 12 segments
111: 11 digits, 11 segments

On power application, the 11-digit, 11-segment mode is selected.

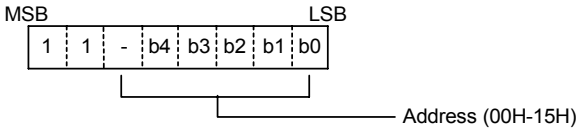
1.2 Data setting commands

These commands set data write and data read modes. On power application, the normal operation and address increment modes are set.

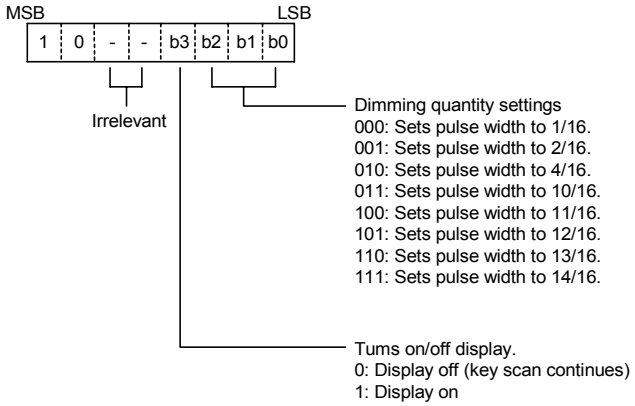

MSB
LSB
0 1 - - b3 b2 b1 b0
Irrelevant
Data write and read mode settings.
00: Write data to display memory.
01: Write data to LED port.
10: Read key data.
11: Read SW data.
Address increment mode settings (display memory).
0: Incremenets address after data has been written.
1: Fixes address.
Test mode settings
0: Normal operation
1: Test mode

1.3 Address setting commands

These commands set an address of the display memory. If address 16H or higher is set, data is ignored, until a valid address is set. On power application, the address is set to 00H.



1.4 Display control commands

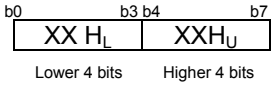

MSB
LSB
1 0 - - b3 b2 b1 b0
Irrelevant
Dimming quantity settings
000: Sets pulse width to 1/16.
001: Sets pulse width to 2/16.
010: Sets pulse width to 4/16.
011: Sets pulse width to 10/16.
100: Sets pulse width to 11/16.
101: Sets pulse width to 12/16.
110: Sets pulse width to 13/16.
111: Sets pulse width to 14/16.
Tums on/off display.
0: Display off (key scan continues)
1: Display on

On power application, the 1/16-pulse width is set, the display is turned off and key scanning is stopped.

2.0 Display RAM Address and Display Mode

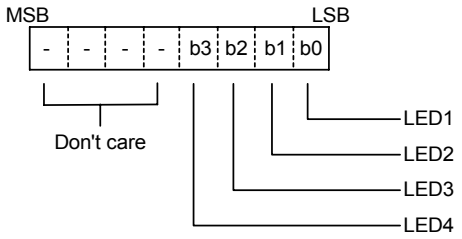
The display RAM stores the data transmitted from an external device to the AD6312 through the serial interface, and is assigned addresses as follows, in 8 bits unit:

Seg_1	Seg_4	Seg_8	Seg_{12}	Seg_{16}	
00 H_L	00 H_U	01 H_L	01 H_U	DIG_1
02 H_L	02 H_U	03 H_L	03 H_U	DIG_2
04 H_L	04 H_U	05 H_L	05 H_U	DIG_3
06 H_L	06 H_U	07 H_L	07 H_U	DIG_4
08 H_L	08 H_U	09 H_L	09 H_U	DIG_5
0 AH_L	0 AH_U	0 BH_L	0 BH_U	DIG_6
0 CH_L	0 CH_U	0 DH_L	0 DH_U	DIG_7
0 EH_L	0 EH_U	0 FH_L	0 FH_U	DIG_8
10 H_L	10 H_U	11 H_L	11 H_U	DIG_9
12 H_L	12 H_U	13 H_L	13 H_U	DIG_{10}
14 H_L	14 H_U	15 H_L	15 H_U	DIG_{11}



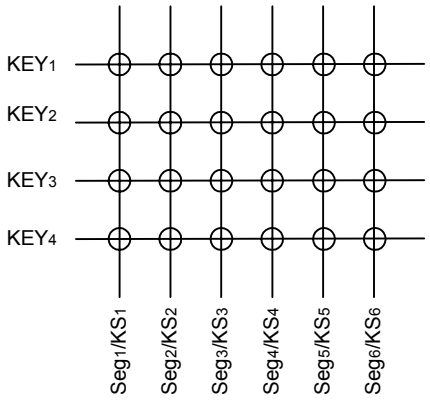
3.0 LED Port

Data is written to the LED port with the write command, starting from the least port's least significant bit. When a bit of this port is 0, the corresponding LED lights; when the bit is 1, the LED turns off. The data of bits 5 through 8 are ignored. On power application, all LEDs are unlit.

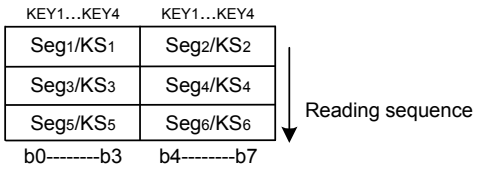


4.0 Key Matrix and Key-Input data Storage RAM

The key matrix is made up of a 6× 4 matrix, as shown below.

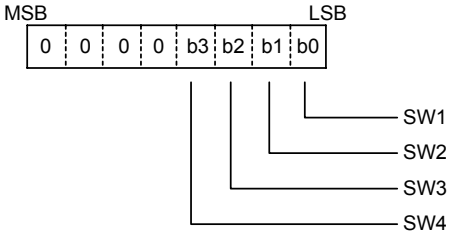


The data of each key is stored as illustrated below, and is read with the read command, starting from the least significant bit.



5.0 SW Data

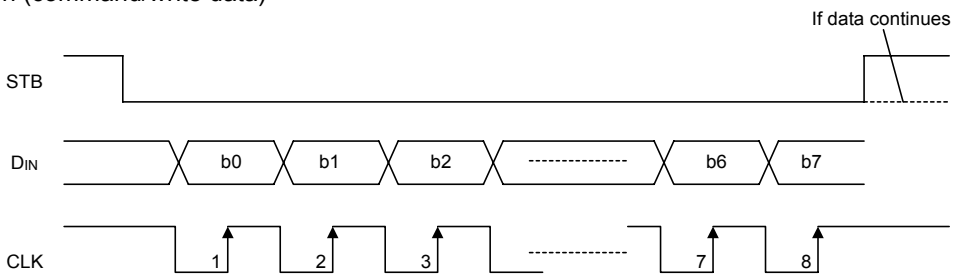
SW data is read with the read command, starting from the least significant bit. Bits 5 through 8 of the SW data are 0.



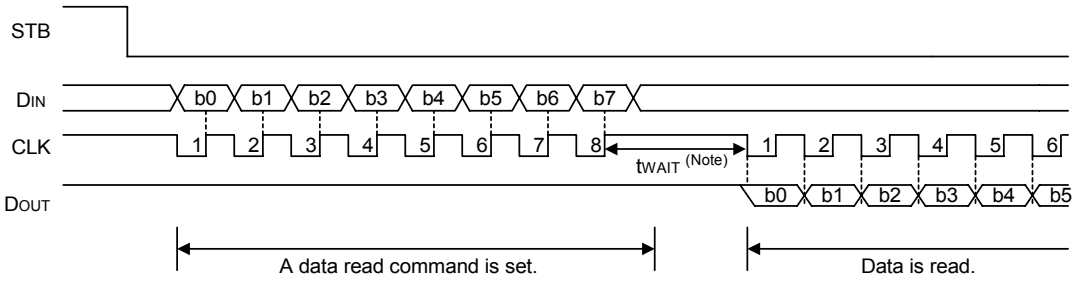
■ Timing Diagram

(1)Serial Communication Format

Reception (command/write data)



Transmission (read data)

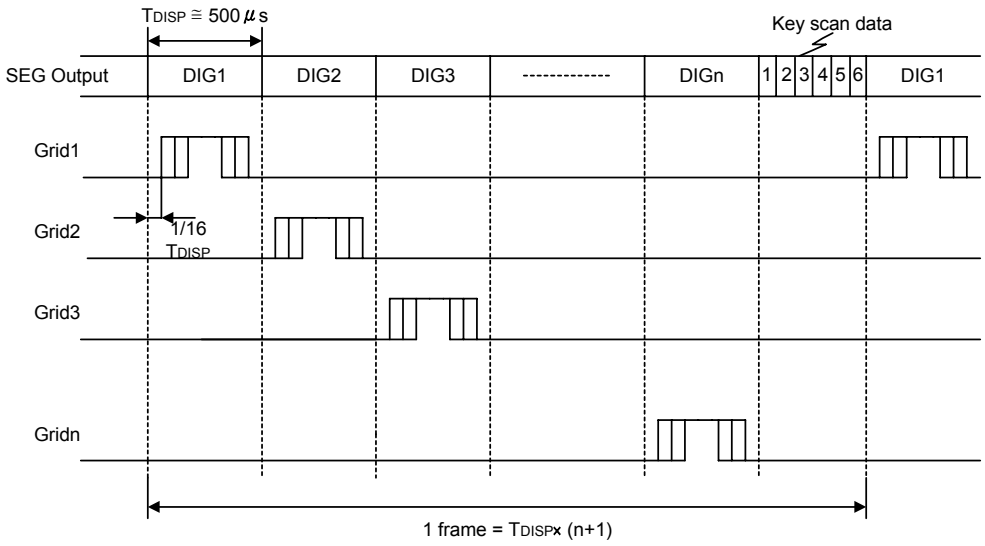


Because the D_{OUT} pin is an N-ch, open-drain output pin, be sure to connect an external pull-up resistor to this pin (1kΩ to 10 kΩ).

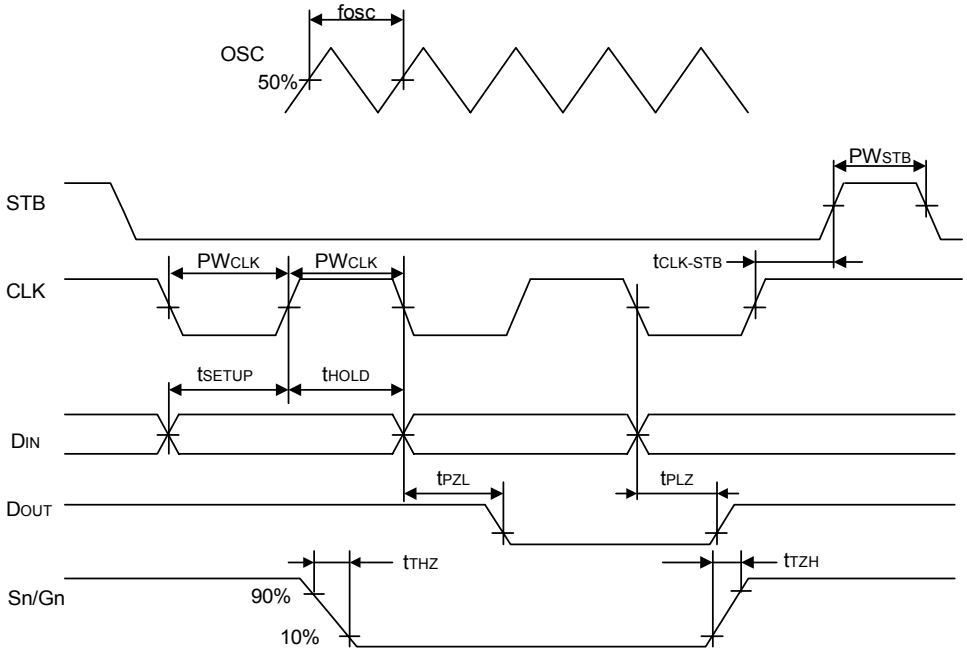
Note : When data is read, a wait time t_{WAIT} of 1 μs is necessary since the rising of the eighth clock that has set the command, until the falling of the first clock that has read the data.

(2)Key Scanning and Display Timing

On cycle of key scanning consists of one frame, and data in a 6× 4 matrix is stored in RAM.

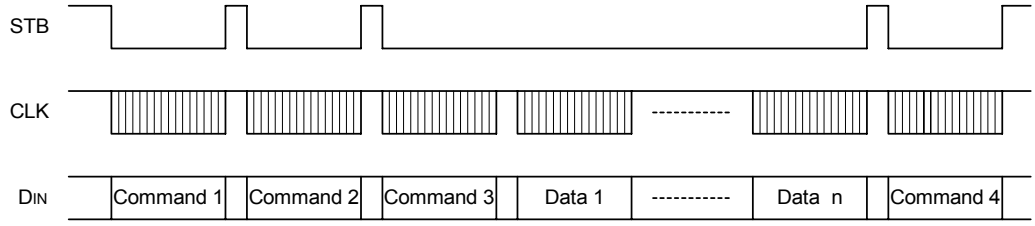


Switching characteristic waveforms



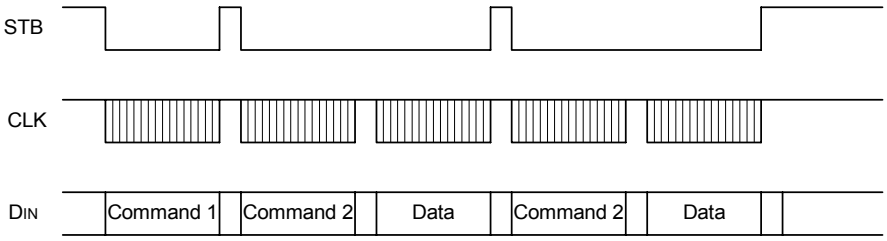
Applications

Updating display memory by incrementing address



Command 1: sets display mode
Command 2: sets data(write data to display memory)
Command 3: sets address
Data 1 to n: transfers display data (22bytes max.)
Command 4: controls display

Updating specific display memory

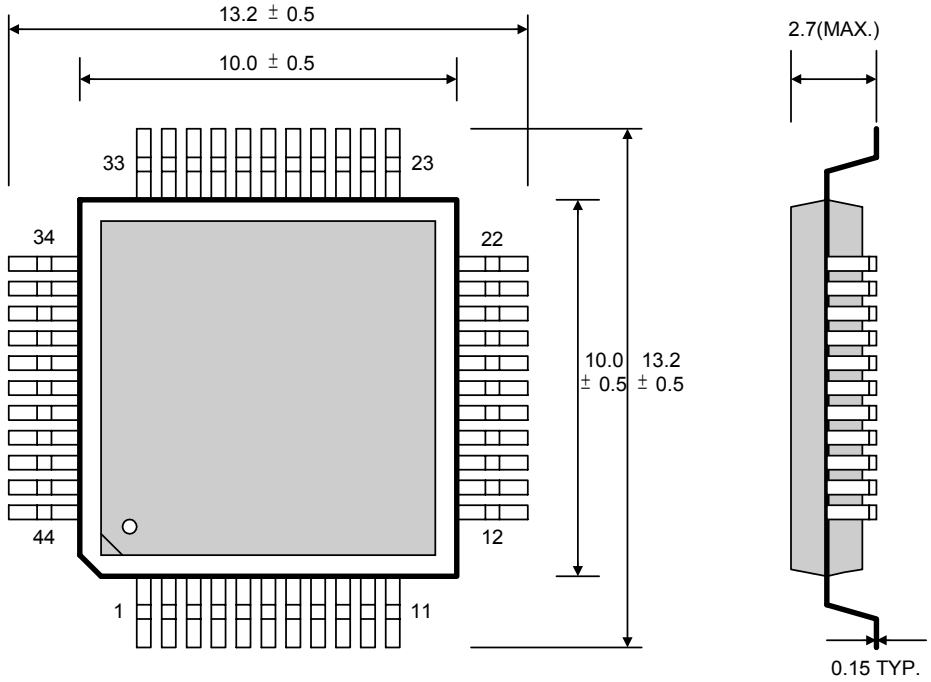


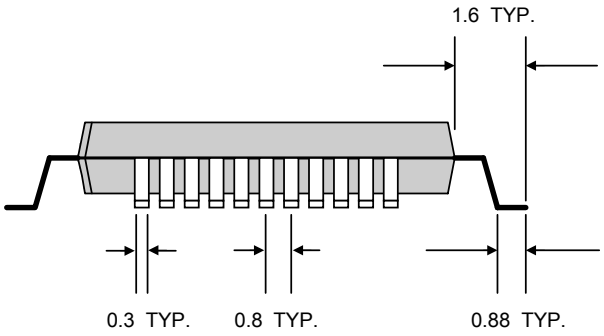
Command 1: sets data
Command 2: sets address
Data: display data

■ Package Information

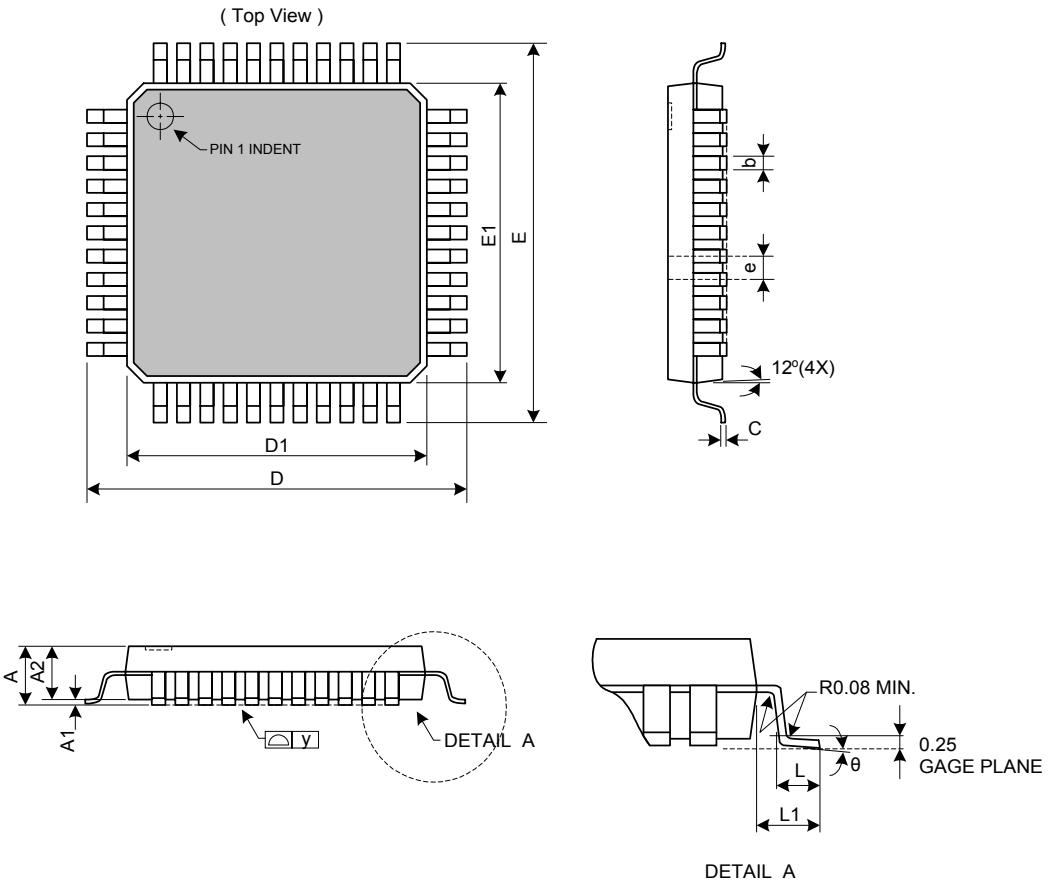
(1) Package Type: QFP-44L

Dimension in millimeter (mm.)



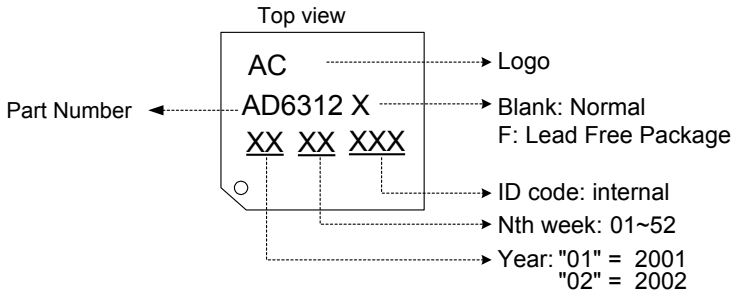


(2) Package Type: LQFP-44L



Symbol	Dimensions In Millimeters			Dimensions In Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	-	-	1.60	-	-	0.063
A1	0.05	0.10	0.15	0.002	0.004	0.006
A2	1.35	1.40	1.45	0.053	0.055	0.057
b	0.30	0.37	0.45	0.012	0.015	0.018
C	0.09	-	0.20	0.004	-	0.008
E	11.50	12.00	12.50	0.453	0.472	0.492
E1	9.50	10.00	10.50	0.374	0.394	0.413
D	11.80	12.00	12.20	0.465	0.472	0.480
D1	9.90	10.00	10.10	0.390	0.394	0.398
e	-	0.80	-	-	0.031	-
L	0.45	0.60	0.75	0.018	0.024	0.030
L1	-	1.00	-	-	0.039	-
θ	0˚	3.5˚	7˚	0˚	3.5˚	7˚
y	0.00	-	0.08	0.000	-	0.003

■ Marking Information



QFP44/LQFP44